

BELLCOMM. INC.

SUBJECT: Extension of Lunar Flying Vehicle
Study to Include Ascent Capability
Case 330

DATE: August 30, 1967

FROM: A. Bresnick

ABSTRACT

The NASA-MSC Lunar Missions Office is presently considering an RFP for a "One Man Lunar Flying Vehicle." This memorandum addresses the question: "Should the scope of the Lunar Flying Vehicle Study be expanded to include an emergency ascent capability to lunar orbit?" It appears unlikely that a lunar surface escape capability can be provided by a simple modification of the baseline Lunar Flying Vehicle.

(NASA-CR-154835) EXTENSION OF LUNAR FLYING
VEHICLE STUDY TO INCLUDE ASCENT CAPABILITY
CASE 330 (Bellcomm, Inc.) 8 p

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MEMORANDUM FOR FILE

Introduction

At the present time the NASA-MSO Lunar Missions Office is considering an RFP for a "One Man Lunar Flying Vehicle" Design/Trade-off Study. The vehicle would be used to facilitate lunar surface exploration.¹ The vehicle would consist of a rocket powered flying device operated by an astronaut and capable of carrying another astronaut or up to 300 lbs. of payload. Prior studies of this concept, by industry, have noted its general similarity to a device that could provide emergency ascent capability from the lunar surface to a lunar orbit.

This memorandum is addressed to a question posed by NASA, Manned Space Flight Safety Office; i.e., "Should the scope of the Lunar Flying Vehicle Study be expanded to include consideration of either an alternate LFV configuration or a dual purpose LFV that provides lunar surface emergency ascent capability to lunar orbit." The following discussion summarizes an evaluation of the baseline LFV to determine its adaptability to the Lunar Ascent Mission, and the extent of modification required to provide ascent capability.

Weight Comparison

The LFV characteristics (from the Statement of Work)² are as follows:

- . Dry weight - 150 to 160 lbs.
- . Propellant capacity - 230 to 275 lbs (N₂O₄ - 50/50)
- . Payload one astronaut and from 0 to 300 lbs. of payload

A comparison of the parameters for the baseline LFV ΔV capability and the one and two-man escape versions can be found in Table I. (All ΔV calculations in this memorandum are based on an Isp assumed to be 257 seconds).

The payload ranges shown in Table I for the various configurations reflect uncertainties in the weight of a pressure suited astronaut with a portable life support system. The payload with one astronaut ranges from 245 to 294 lbs., for both the baseline vehicle and the one-man ascent configurations. (This payload weight should not be confused with the baseline vehicle maximum design payload of one fully equipped astronaut and up to 300 lbs.) The payload is twice as large or 490 to 588 lbs., for a two-man baseline vehicle or ascent configuration. The ΔV for the baseline LFV in Table I is the maximum available and ranges from 3,930 to 4,295 ft/sec. for a one-man payload, and from 2,590 to 2,920 ft/sec. for a two-man payload. The ΔV required for any ascent mission is tabulated in Table I as 6,600 ft/sec. This is close to the absolute minimum velocity requirement necessary to escape from the lunar surface and provide orbital insertion at the nominal CSM altitude of 80 N. M. Additional ΔV capability would be necessary to provide for plane changing, rendezvous maneuvering, and for navigational error compensation.

Table I shows the one and two-man vehicle dry weights which were increased by 10 and 20 percent respectively over the baseline LFV configuration to account for estimated additional tankage and structural requirements.

The propellant required for the one and two-man vehicles is approximately double and triple respectively the maximum available propellant on the baseline LFV. The actual propellant weights are listed in Table I. The propellant, and vehicle weight ranges for each ascent configuration has resulted from the uncertainty in the weight of the equipped astronaut(s). The last column in Table I lists the total vehicle gross weight for the baseline vehicle and the ascent configurations. It is apparent that the one-man ascent mode gross weight is about 50% larger than a one-man LFV and the two-man ascent mode gross weight about 100% larger.

To achieve a one-man ascent escape mission, it is conceivable that the required ΔV could be achieved by the use of strapped-on propellant tanks. To achieve a two-man ascent escape mission would undoubtedly require a new vehicle design.

In order to enable ascent of two astronauts from the lunar surface, two one-man LFV's or one two-man LFV would be required. From Table I, the maximum weight addition to a lunar mission would result from two one-man LFV's or approximately 352 lbs.; this would require the availability of from 1,028 to 1,146 lbs. of propellants on board the LM. It would be much more advisable, at least from a weight penalty viewpoint, to utilize a two-man LFV escape device which would have a lunar mission weight addition of only 192 lbs. and would require the availability of from 831 to 952 lbs. of LM propellants.

Other Considerations

Provision of an escape capability would entail changes to the baseline LFV that are in all probability more extensive than that which is indicated by the above propulsion comparison. Analyses would have to be made of various subsystems, mission requirements, and operations such as:

1. Guidance

- a. The guidance accuracy required - The guidance technique and the accompanying sight proposed by Bell Aerosystems³ is a novel approach which would have to be proved by appropriate simulations.
- b. The capability to rendezvous with an orbiting CSM.

2. Life Support and Requirements

The present PLSS has very limited capability¹ and might not support CSM rendezvous time requirements.

3. Communications

4. Astronaut Harnesses

5. Orbital Dispersion

If two LFV's are used to rescue the LM crew, their allowable orbital dispersion, both in altitude and orbital plane, would be limited by the sequential rendezvous capability of the CSM. This could impose a severe guidance accuracy requirement on the one-man ascent mode. This dispersion problem could be solved by coupling two one-man LFV's together for the ascent from lunar surface mission. However, coupling of two LFV's would present a whole new set of problems headed by such factors as means of coupling and differential thrust control as well as potential C. G. and balance problems.

6. LM Propellant Availability

The LFV propellant required to achieve lunar orbit has been assumed to be available in the LM, however, this may not be correct under all circumstances.

7. LFV Stowage and Assembly


If the LFV is to be stowed as sub-assemblies aboard the LM and assembled and fueled by the astronaut(s) on the lunar surface, the required tasks must be simple and easy to perform by a pressure suited, astronaut.

8. LFV Fueling

It would be highly preferable for the astronaut(s) not to perform any fueling tasks but rather to rely on an automatic docked fueling station configuration for the LFV.

Conclusion

It appears unlikely that a lunar surface escape capability can be provided by a simple modification of the baseline LFV. Considerable effort beyond the scope of the present LFV study RFP would be required to identify the ascent vehicles requirements, and configuration differences. Before such effort is expended, the rationale and operational requirements for a lunar surface emergency ascent vehicle to enhance safety on lunar missions should be developed.



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Attachment
References

TABLE I

Configuration	Mission	Dry Weight lbs.	Propellant Weight lbs.	Vehicle Weight Plus Propellant	ΔV ft/sec	Payload Weight lbs.	Vehicle Gross Wt. lbs.
Baseline LFV	Lunar Flight with One Astronaut	160	275	435	3,930-4,295 (Available)	245-294	680-729
Baseline LFV	Lunar Flight with Two Astronauts	160	275	435	2,590-2,920 (Available)	490-588	925-1,023
One Man Ascent	Escape of One Astronaut from Lunar Surface	176	514-573	690-749	6,600 (Required)	245-294	935-1,043
Two Man Ascent	Escape of Two Astronauts from Lunar Surface	192	831-952	1,023-1,144	6,600 (Required)	490-588	1,513-1,732

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REFERENCES

1. R. Sehgal, "Lunar Surface Mobility Systems for Lunar Exploration," Case 232, Memorandum for File, July 10, 1967.
2. NASA-MSO, Lunar Missions Office, Work Statement, "One Man Lunar Flying Vehicle," Revision A, May 17, 1967.
3. Bell Aerosystem Company, Presentation on "Lunar Surface Rescue and Escape," Report No. 7296-953001.

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Vehicle Study to Include
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